Results of a Marine Recreational Chinook and Coho Catch and Release Mortality Study Conducted in the Lower Strait of Georgia During 2001

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RESULTS OF A MARINE RECREATIONAL CHINOOK AND COHO CATCH AND RELEASE MORTALITY STUDY CONDUCTED IN THE LOWER STRAIT OF GEORGIA DURING 2001

by

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ABSTRACT

Diewert, R.E., D.A. Nagtegaal, and J. Patterson. 2002. Results of a marine recreational chinook and coho catch and release mortality study conducted in the lower Strait of Georgia during 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2625: 32 p.

In 2002, the Biological Sciences Branch, Pacific Biological Station, conducted a study of chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon catch and release mortality in a southern Strait of Georgia recreational fishery. For all species combined, the immediate landed mortality rate was 19.4% (95% CL: 16.0% to 23.3%). While the immediate mortality rate was higher for coho (21.0%; 95% CL: 17.1% to 25.8%) than for chinook (14.0%; 95% CL: 7.6% to 24.8%); the difference was not statistically significant (chi-square = 1.478; p = 0.05). An assessment of several factors revealed that hook location, bleeding and fish size contributed significantly to the coho immediate mortality rate while hook location, bleeding, scaling and angler activity contributed significantly to chinook immediate mortality.

Short term delayed mortality was assessed by holding a portion of the landed catch in a net pen for approximately 24 h. Overall delayed mortality rates were 12.0% for coho, 50.0% for chinook and 14.8% for both species combined. The only significant factor influencing delayed mortality was arrival condition at the net pen.

The effect of marine mammal predation on non-landed (drop off) hooking mortality was assessed by having anglers record details relating to encounters with marine mammals that occurred while fishing. A total of 29 marine mammal encounters were recorded over 144 fishing trips yielding an encounter rate 0.20 per trip. Marine mammal encounters were further examined by fish species hooked and encounter type. The total encounter rate per hook-up for all species combined was 0.054. Over a total of 436 coho hook-ups, 14 seal encounters were recorded yielding a rate of 0.032. For chinook, a total of 11 seal encounters were recorded for 102 hook-ups yielding a rate of 0.108.

RÉSUMÉ

Diewert, R.E., D.A. Nagtegaal, and J. Patterson. 2002. Results of a marine recreational chinook and coho catch and release mortality study conducted in the lower Strait of Georgia during 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2625: 32 p.

En 2002, la direction des Sciences biologiques de la Station de biologie du Pacifique a réalisé une étude sur la mortalité due à la capture avec remise à l'eau des quinnats (*Oncorhynchus tshawytscha*) et des cohos (*O. kisutch*) dans une pêche sportive du sud du détroit de Georgia. Pour les deux espèces combinées, le taux de mortalité immédiate au débarquement était de 19,4 % (95 % LC : 16,0 % à 23,3 %). Alors que le taux de mortalité immédiate était plus élevé pour les cohos (21,0 %; 95 % LC : 17,1 % à 25,8 %) que pour les quinnats (14,0 %; 95 % LC : 7,6 % à 24,8 %), la différence n'était pas statistiquement significative (chi carré = 1,478; p = 0,05). L'évaluation de plusieurs facteurs a révélé que le point d'accrochage de l'hameçon, le saignement et la taille du poisson contribuaient de façon notable au taux de mortalité immédiate chez les cohos, alors que, chez les quinnats, c'étaient le point d'accrochage de l'hameçon, le saignement, la perte d'écailles et l'activité du pêcheur qui contribuaient de façon notable au taux de mortalité immédiate.

Nous avons évalué la mortalité différée à court terme en maintenant une partie des poissons débarqués dans un enclos de filet pendant environ 24 h. Les taux globaux de mortalité différée étaient de 12,0 % pour les cohos, 50,0 % pour les quinnats et 14,8 % pour les deux espèces combinées. Le seul facteur qui influait de façon notable sur la mortalité différée était l'état des poissons à l'arrivée dans l'enclos.

Nous avons évalué l'effet de la prédation par les mammifères marins sur la mortalité des poissons non débarqués (décrochés) en demandant aux pêcheurs de consigner des détails sur les rencontres avec des mammifères marins survenues pendant la pêche. Au total, 29 rencontres avec des mammifères marins ont été notées au cours de 144 sorties de pêche, soit un taux de rencontre de 0,20 par sortie. Les rencontres avec des mammifères marins ont été examinées en fonction de l'espèce de poisson pris à l'hameçon et du type de rencontre. Le taux total de rencontre par poisson pris à l'hameçon, les espèces étant combinées, était de 0,054. Sur un total de 436 cohos pris à l'hameçon, on a noté 14 rencontres avec des phoques, soit un taux de 0,032. Pour les quinnats, on a noté un total de 11 rencontres avec des phoques pour 102 poissons pris à l'hameçon, soit un taux de 0,108.

INTRODUCTION

Chinook and coho stocks are invaluable to both the commercial and recreational fisheries of the Pacific Northwest (Collicut and Shardlow 1995). In spite of protective measures, the overall abundance of many stocks of chinook and coho salmon has continued to decline. This negative trend has potential ramifications regarding the sustainability of British Columbia's fishing industry (Argue et al. 1983). A thorough understanding of all sources of mortality is required to formulate and implement effective management strategies to protect fragile stocks while maintaining a viable fishery. In the recreational sector, unrecorded mortality associated with the release of angled fish is currently estimated based on the results of a few studies carried out in northern British Columbia (Cox-Rogers 2001). Research indicates that hooking mortality can vary for the same species captured on similar gears in different fishing areas (Cox-Rogers *et al.* 1999). This variability occurs as hooking mortality is influenced by a wide range of factors including fishing technique, fish size, fish behaviour and aggressiveness, food availability, fish abundance, stage of maturity, water temperature, depth of capture, hook size and type, and angler skill in playing, landing and releasing fish (Muoneke and Childress 1994).

Hooking mortality is generally broken down into two major components consisting of landed mortality and non-landed mortality. In the landed mortality category there is both immediate mortality, that is fish that are dead when landed, and delayed mortality where captured fish are alive but die after release from injuries or handling stress. In the non-landed mortality category, fish that escape the gear encounter prior to landing die because of the encounter itself or due to associated mortality resulting from subsequent predation, long-term effects or regulation non-compliance (CTC 1997).

During 2001, the Biological Sciences Branch of the Canadian Department of Fisheries and Oceans implemented a study to examine hooking mortality in a marine recreational fishery operating in the southern Strait of Georgia, British Columbia. Objectives of the study included:

1) documenting immediate landed mortality rates for coho and chinook,
2) documenting short term delayed mortality rates for coho and chinook,
3) examining the effects of several angling related factors on immediate and delayed mortality, and
4) examining marine mammal encounter rates and estimating the resulting impact on non-landed mortality.

METHODOLOGY

STUDY AREA AND FISHING METHODS

The 2001 hooking mortality study was conducted at two popular recreational fishing areas in the southern Strait of Georgia near Nanaimo, British Columbia (Figure 1). The first study site was located near French Creek in DFO statistical area 14, where angling was

monitored from June 13 to October 13, 2001. The second site was located directly off the city of Nanaimo in DFO statistical area 17, where angling was monitored from June 16 to September 28, 2001.

Anglers were contacted and selected through local sportsmen's clubs and tackle supply shops. The intent was to use recreational fishers with a wide range of experience to ensure that study results reflected the actual fishery. Selected anglers fished from their own boats using a variety of terminal tackle. The most popular fishing method was trolling flashers and lures from downriggers. Other methods employed included drift fishing with jigs and trolling natural baits (e.g. herring strip) from a downrigger.

FISH HANDLING AND DATA COLLECTION

Anglers fished using their typical techniques, gear and fish handling procedures. Each participant was trained in fish sampling, tagging and data collection protocols. Trained observers were placed aboard some of the fishing vessels to ensure data collection procedures were rigorously followed. For each fish encounter, time from hook up to landing, gear description, hooking location, degree of bleeding, location of bleeding, degree of scaling, general fish condition, and nose-fork length were recorded. A uniquely numbered t-bar anchor tag was applied below the dorsal fin insertion on the left side of each fish. Care was taken to ensure that the tag was well anchored between the pterygiophore bones. The condition of each fish at release was recorded as 1 (swam away vigorously), 2 (swam away slowly), 3 (required ventilation), or 4 (dead).

FISH TRANSPORT AND HOLDING

A subset of all fish captured were transported to a holding pen to monitor short term (approximately 24 hour) delayed mortality. Fish destined for the holding facility were held in PVC tubes while the transport vessel was contacted using a VHF radio. The transport boat (a 5.5 m zodiac) was equipped with a 256 litre holding tank outfitted with a locking lid. Air was supplied to the tank from a regulated, compressed air cylinder via PVC tubing and an air stone. Insulation in the tank structure ensured that water temperature in the tank remained at or near ambient sea surface temperature.

The net pen was located near the fishing grounds at the French Creek Marina thus ensuring minimal transport times. The pen was constructed by hanging a net from an aluminum rotary screw trap frame. The net measured 9.29 m by 9.29 m in width and was 6.10 m deep. While an inner net held fish, additional nets surrounded the structure providing protection from predation. A dark blue polypropylene tarp was place on top of the pen to provide shading and cover. All nets were pulled once a week to control algal growth, which ensured that adequate water exchange occurred within the pen.

Data recorded for all fish arriving at the net pen included species, nose-fork length, adipose fin status, transport time and general fish condition. Five scales were removed from the mid-lateral area between the dorsal and anal fins for age analysis. After a minimum of 24 hours, fish were released outside the marina breakwater where water depth reached approximately 60 m. Condition at release was noted along with any other pertinent information.

MARINE MAMMAL PREDATION

Non-landed mortality associated with marine mammal predation was assessed by having anglers record details relating to encounters with marine mammals that occurred while fishing. Encounters were grouped into the following four categories: 1) line reeled in with salmon remains (partial carcass), 2) line reeled in with salmon in predator's mouth, 3) fish lost as line is being retrieved, then a marine mammal is observed in the area with a fish in it's mouth, and 4) fish lost as line is being retrieved, marine mammals observed in the area. The first two encounter types were considered as confirmed encounters while the last two were catagorized as implied encounters. Anglers and observers also recorded date, time, gear type, the size and number of marine mammals present and their distance from the boat.

STATISTICAL ANALYSIS

Statistical analysis of all data followed the procedures outlined in Cox-Rogers (2001), which are presented below.

Mortality rates were calculated using a simple proportion calculation from a binomial distribution (Zar 1984). The observed mortality rate was calculated as:

$$1) \qquad \hat{P} = \frac{x}{n}$$

where $\hat{P}$ is the mortality rate estimate, x is the number of fish mortalities, and n is the total number of fish sampled. Landing rates were calculated in the same way. Using a relationship between the F distribution and the binomial distribution, lower (L_1) and upper (L_2) confidence limits about P were calculated as follows (Zar 1984):

$$2) \qquad L_1 = \frac{x}{x+(n-x+1)F_{0.05(2)\nu 1,\nu 2}} \qquad \text{with } \nu_1 = 2(n-x+1) \text{ and } \nu_2 = 2x$$

$$\frac{(x+1)\,F_{0.05(2)\nu 1,\nu 2}}{}$$

3) $L_2 = \frac{}{n-x+(x+1)F_{0.05(2)\upsilon_1,\upsilon_2}}$ with $\upsilon_1 = 2(x+1)$ and $\upsilon_2 = 2(n-x)$

Contingency analysis was used to assess the dependence of mortality on various factors including hooking location, degree of bleeding, fish size, degree of scaling and angler activity.

RESULTS

Over the duration of the hooking mortality study, a total of 310 coho and 93 chinook salmon were landed, sampled and completely assessed. In addition, 105 coho and 14 chinook were landed without sampling or complete assessment. This generally occurred when multiple hook-ups precluded following the assessment protocol on all fish.

A total of 34 individual anglers participated in the study. Angling experience ranged from novice to expert. The vast majority of anglers (98.5%) chose to troll using a downrigger while only 1.5% employed a drift fishing technique. The most popular terminal gear was a lure and flasher combination (93.6%) with lure only and a combination of bait and flasher distant second and third choices (4.2% and 2.2%, respectively) (Table 1).

The vast majority of landed coho and chinook were captured using a single hook (99.0% and 92.5%, respectively) as opposed to a treble hook. A total of 28.7% of landed coho and 8.6% of landed chinook were captured on gear that included a trailing hook. The majority of coho were landed on size 5/0 hooks (49.7%) while most chinook were landed on size 3/0 hooks (37.6%) (Table 1).

LANDING RATES

Landing rates were calculated by area and species and represent the total proportion of hook-ups that resulted in fish being landed at the boat. While a significant number of lost fish could not be identified to species, visual identification was possible for many unlanded fish and therefore species specific, as well as total landing rates, were calculated (Table 2).

A total of 522 landings from 1163 hook-ups resulted in a landing rate of 44.9% for all areas and species combined. In Area 14, the landing rate for chinook (58.7%) was higher than for coho (47.7%); however, this trend was reversed in Area 17 where the coho landing rate exceeded the rate for chinook (61.0% and 52.9%, respectively). For all areas combined, the landing rate for chinook (56.6%) was greater than the landing rate for coho (48.3%). When all species were combined by area, the landing rate in Area 17 (51.7%) was greater than the rate in Area 14 (44.1%) (Table 2). A comparison of the effect of gear type on landing rates could not be undertaken due to the overwhelming choice of a single fishing technique (trolling with downrigger and lure).

MORTALITY RATES

Hooking mortality rates were examined for both landed and non-landed fish. The landed component was further broken down into immediate and delayed mortality.

Landed - Immediate Mortality

A total of 310 coho and 93 chinook were landed, released and assessed to determine immediate mortality rates. Those that were dead when landed or could not be revived when released were considered immediate mortalities. For all species combined, the immediate mortality rate was 19.4% (95% CL: 16.0% to 23.3%). Mortality rates were also determined for each species and area separately and ranged from a low of 6.5% (95% CL: 0.8% to 21.4%) for chinook in Area 17 to a high of 33.3% (95% CL: 14.6% to 57.0%) for coho in Area 17 (Table 3). There was no statistically significant difference between the mortality rates observed in Area 17 (17.3%; 95% CL: 8.2% to 30.4%) and that observed in Area 14 (19.7%; 95% CL: 16.0% to 23.7%) when all species were combined (chi-square = 0.883; p = 0.05) (Table 3).

When data from both areas were combined, the mortality rate was higher for coho (21.0%; 95% CL: 17.1% to 25.8%) than for chinook (14.0%; 95% CL: 7.6% to 24.8%); but the difference was not statistically significant (chi-square = 1.478; p = 0.05). There was also no difference between the mortality rates of coho and chinook in Area 14 (chi-square = 0.119; p = 0.05); however, immediate mortality rates were significantly higher for coho in Area 17 than for chinook (chi-square = 4.118; p = 0.05) (Table 3).

Hook Location: The effect of hooking location on the release condition of landed fish was examined by stratifying the data, by species, into release condition and hooking location (Table 4). For both coho and chinook, none of the fish released alive (release codes 1, 2 or 3) were hooked in the deep mouth. In contrast, 86.2% of coho immediate mortalities and 84.6% of chinook immediate mortalities were hooked in the deep mouth (Table 4, Figures 2 and 3). Further, 92.2% of coho and 94.9% of chinook released alive were hooked in the outer mouth.

Contingency analysis revealed that there was a statistically significant difference between hooking location and release condition (live versus dead) for coho and chinook (chi-square = 255.904 and 75.765, respectively; p = 0.05).

Bleeding: The effect of the degree of bleeding on the release condition of landed fish was examined by stratifying the data, by species, into release condition and degree of bleeding (Table 5a). For both coho and chinook, the majority of the fish released alive (release codes 1, 2 or 3) exhibited either light or no bleeding (69.3% and 84.8%, respectively). In contrast, 84.4% of the coho and 76.9% of the chinook immediate mortalities exhibited either moderate or heavy bleeding (Table 5a, Figures 4 and 5).

Contingency analysis revealed that there was a statistically significant difference between degree of bleeding and release condition (live versus dead) for coho and chinook (chi-square = 77.068 and 15.340, respectively; p = 0.05).

All fish that exhibited bleeding were stratified by release condition and location of bleeding (Table 5b). For both coho and chinook, the majority of the fish released alive bled from the jaw or maxillary areas (66.7% and 64.7%, respectively) and no fish in this category bled from either the gills or deep mouth. In contrast, 53.3% of coho immediate mortalities and 62.5% of chinook immediate mortalities exhibited bleeding from either the deep mouth or gills (Table 5b).

Contingency analysis revealed that there was a statistically significant difference between bleeding location and release condition (live versus dead) for coho and chinook (chi-square = 46.801 and 17.591, respectively; p = 0.05).

Fish Size: The length frequency distributions of fish released alive and landed mortalities were compared for coho and chinook. The nose-fork lengths of coho released alive ranged from 22.0 to 70.0 cm and averaged 53.6 cm while the lengths of landed coho mortalities ranged from 21.0 to 64.0 cm and averaged 49.6 cm (Table 6, Figures 6 and 7). Statistical analysis revealed that coho mortalities were significantly smaller than fish released alive (Student's t-test: t=3.2386, p=0.05). The nose-fork lengths of chinook released alive ranged from 38.0 to 100.0 cm and averaged 63.1 cm while the lengths of landed chinook mortalities ranged from 47.0 to 77.0 cm and averaged 63.9 cm (Table 6). Statistical analysis revealed no significant difference between chinook live releases and mortalities (Student's t-test: t=0.1838, p=0.05).

Handling: The total elapsed time from hook-up to landing ranged from 1 to 15 min and averaged 3 min 45 s for coho. Total elapsed time from hook-up to landing for chinook ranged from 1 to 36 min and averaged 6 min 39 s. The majority of coho and chinook were netted as part of the landing procedure (69.7% and 78.3%, respectively). Boat contact was common as 74.0% of coho and 64.4% of chinook impacted the boat at some point during handling. Exposure to air ranged from 0 to 150 s and averaged 34.8 s for coho and ranged from 0 to 120 s and averaged 23.1 s for chinook.

Scale loss resulting from handling procedures can have a detrimental effect on the survival of released fish. The effect of the degree of scaling on the release condition of landed fish was examined by stratifying the data, by species, into release condition and degree of scaling (Table 7). The majority of both coho live releases (release codes 1, 2 or 3) and immediate mortalities exhibited light scaling (71.3% and 61.7%, respectively) and there was no significant difference in degree of scaling between the groups (chi-square = 6.941; p = 0.05). While the majority of chinook live releases also showed light scaling (65.8%), the majority of chinook mortalities exhibited a moderate level of scale loss (36.4%) (Table 7). In the case of landed chinook salmon, there was a significant difference in the degree of scaling between live releases and immediate mortalities (chi-square = 8.198; p = 0.05).

Angler Activity: The actions that anglers take to secure a hook-up may have an effect on subsequent mortality rates. Angler activity in the current study was catagorized as no action

taken, strike to set the hook or fed line. The effect of angler activity on the release condition of landed fish was examined by stratifying the data, by species, into release condition and angler activity (Table 8). For coho, angler activity for all release conditions was dominated by striking to set the hook (89.2%) and there was no significant difference in angler activity between live releases and immediate mortalities (chi-square = 3.485; p = 0.05). Angler activity was much more diverse for chinook. While striking to set the hook remained the most popular activity (58.2%) both feeding line (11.0%) and taking no action (30.8%) were also common practices. Contingency analysis revealed that there was a significant difference in angler activity between live releases and immediate mortalities for chinook (chi-square = 7.592; p = 0.05) with a higher proportion of the mortalities in the fed line category (23.1%) (Table 8).

Landed - Delayed Mortality

A total of 50 coho and 4 chinook were held in a net pen to assess short-term delayed mortality. Holding time ranged from 24.0 to 29.0 h and averaged 25.9 h for coho, and ranged from 25.0 to 30.0 h and averaged 27.8 h for chinook (Table 9). Except for the coho assessed as dead on arrival, holding time until death could not be ascertained as the net pen was not checked between fish arrival and release. Overall mortality rates were 12.0% for coho, 50.0% for chinook and 14.8% for both species combined (Table 9).

The condition of all fish was assessed on arrival at the net pen. Thirty-three coho arrived in good condition while 12 were assessed as fair, three poor and two dead on arrival. Two chinook arrived in good condition and two in fair condition (Table 10).

The relationship between release condition and arrival condition was examined for all coho held at the net pen facility (Table 10). No chinook assessment was possible due to the small sample size The majority of coho released alive from the net pen arrived in good (68.2%) or fair (27.3%) condition while only 4.5% were assessed as poor. In contrast, 50.0% of the coho mortalities arrived in poor condition or were dead on arrival while 50.0% were assessed as good. Contingency analysis revealed that arrival condition had a significant impact on coho delayed mortality rates (chi-square = 17.860; p = 0.05).

Hook Location: The effect of hooking location on the release condition of coho held in the net pen was examined by stratifying the data into release condition and hooking location (Table 11). The vast majority of coho released alive were hooked in the outer mouth (90.9%), while only a few were hooked in the deep mouth area (9.1%). All coho mortalities were also hooked in the outer mouth and contingency analysis revealed that there was no statistically significant difference between hooking location and release condition (live versus dead) for coho held in the net pen (chi square = 0.593; p = 0.05).

Bleeding: The effect of the degree of bleeding on the release condition of coho held in the net pen was examined by stratifying the data into release condition and degree of bleeding (Table 12a). The majority of coho released alive exhibited either light or moderate bleeding (59.1% and 34.1%, respectively). Coho net pen mortalities also showed either light or moderate bleeding (50% each) and contingency analysis revealed that there was no statistically significant

difference between degree of bleeding and release condition for coho held in the net pen (chi square = 0.856; p = 0.05).

A sub sample of the coho that exhibited bleeding were stratified by release condition and location of bleeding (Table 12b). The majority of coho released alive bled from the jaw or maxillary areas (94.4%) while the remainder bled from the gills. Coho mortalities also bled primarily from the jaw and maxillary areas (75.0%) or from the eye (25.0%). Contingency analysis revealed that there was no statistically significant difference between bleeding location and release condition (live releases dead) for coho held in the net pen (chi-square = 4.858; p = 0.05).

Fish Size: The length frequency distribution of coho held in the net pen was compared to all coho landed during the study. The nose-fork lengths of net pen coho ranged from 44.0 to 68.0 cm and averaged 56.4 cm. Statistical analysis revealed that coho held in the net pen were significantly larger than the landed coho population (Student's t-test: t=4.589; p=0.05). The lengths of live released coho were not compared to the lengths of coho net pen mortalities due to small sample sizes.

Handling: All of the coho released alive from the net pen exhibited either light or moderate scaling (79.5% and 20.5%, respectively) (Table 13). All coho net pen mortalities also showed either light or moderate scaling (66.7% and 33.3%, respectively) and there was no significant difference in the degree of scaling between live releases and moralities (chi-square = 0.510; p = 0.05).

Angler Activity: The actions that anglers take to secure a hook-up may have an effect on subsequent mortality rates. For coho held at the net pen facility, angler activity for all release conditions was dominated by striking to set the hook (Table 14). A total of 93.2% of the coho released alive from the net pen were captured by anglers striking to set the hook and 100% of coho moralities were in the strike category. Contingency analysis revealed that there was no significant difference in angler activity between live releases and mortalities (chi-square = 0.435; p = 0.05).

A review of the significance of the effect of all factors on immediate and delayed mortality for chinook and coho is presented in Table 18.

Non-Landed Mortality– Marine Mammal Predation

The marine mammal predation portion of the hooking mortality study was conducted between June 13 and October 9. A total of 14 anglers participated in the project embarking on 144 fishing trips in DFO statistical areas 14 and 17 (Figure 1). The majority of the effort occurred in Area 14 (94% of all fishing trips) mirroring general fishing effort patterns. While anglers participating in the project fished throughout the study period, peak fishing occurred from the middle of August to the end of September (Table 15).

All marine mammals encountered during the study were identified as harbour seals (*Phoca vitulina*). The number of seals involved in each encounter ranged from one to ten but in most cases was either one or two animals. A total of 29 seal encounters were recorded over 144 trips yielding an encounter rate of 0.20 per trip. Seal encounter rate per fishing trip was higher in Area 17 (0.63) than in Area 14 (0.18) indicating that seal abundance may be higher in the fishing grounds near Nanaimo.

The temporal pattern of seal encounters was assessed by stratifying the data into three-week periods and examining the number of encounters per fishing trip that occurred in each period. Encounters per fishing trip ranged from a high of 1.75 in early July to a low of 0.10 in early September. Encounters were generally higher at the beginning of the study period and declined by the middle of August, remaining at low levels to the end of the project (Table 15).

Marine mammal encounters were examined by fish species hooked and encounter type (Table 16). The total encounter rate per hook-up for all species combined was 0.054. Over a total of 436 coho hook-ups, 14 seal encounters were recorded yielding a rate of 0.032. For chinook, a total of 11 seal encounters were recorded for 102 hook-ups yielding a rate of 0.108. The species hooked could not be identified for the remaining 4 encounters (Table 16).

DISCUSSION

The prevalence of catch and release fisheries is increasing as managers search for strategies that will allow continued fishing opportunities while ensuring the protection of wild salmon stocks. As a result, a thorough understanding of the level of mortality associated with the release of salmon captured by angling is vital. While other studies have been conducted in recent years, results can vary for the same species captured on similar gears in different fishing areas as hooking mortality is influenced by a wide range of factors (Cox-Rogers *et al.* 1999). The current study focused on an area of high angler effort located close to a large metropolitan centre in the southern Strait of Georgia. Results from this study are likely more reflective of hooking mortality rates in this particular fishery and should be considered by managers for use in estimating total fishery impacts.

Data collected throughout British Columbia indicates that the gear utilized by recreational anglers varies dramatically with geographic region. In our study area, anglers trolled artificial lures from downriggers almost exclusively. This gear choice reflects a recent dramatic shift in angler gear preference that occurred between 1999 and 2000 (Table 17, Figure 8). Data collected by creel survey interviewers indicates that while the vast majority of anglers fishing for chinook and coho in DFO statistical areas 14 and 17 trolled with bait in 1999, the gear of choice switched to trolling with downrigger and lure the following year. This observation suggests that variation in gear preference occurs temporally as well as spatially and that changes can develop very quickly. Further, as the type of gear employed can impact hooking mortality rates it is important that this type of data continue to be collected and that potential impacts on landed and non-landed mortality be considered.

The overall landing rate observed in the current study was 44.8%; however, the rates varied by area and species. Other studies have shown similar variation in landing rates by area, gear type and species. A study conducted on coho in 3 northern BC areas found landing rates that ranged from 41.9% to 69.2% with an overall rate of 57.7% (Cox-Rogers 2000). A similar study focusing on chinook in a single area revealed landing rates ranging from 37.5% to 90.9% with an overall rate of 64.1% (Cox-Rogers 2001). The landing rates observed in the current study were in the low end of this range, which may reflect area specific influences or may be a result of the inclusion of many novice and moderately experienced anglers in the study.

When data from all areas were combined, landing rates were lower for coho than chinook. This result has been observed in other studies (Cox-Rogers 2000, 2001) and it is generally felt that this occurs due to the propensity of coho to resist gear and fight more readily. While we found the reverse trend in Area 17, the sample size was relatively small and may not have been representative of the true landing rate.

LANDED – IMMEDIATE MORTALITY

The immediate landed mortality rate for all areas and species combined was 19.4%; however, rates varied by area and species ranging from a low of 6.5% for chinook in Area 17 to a high of 33.3% for coho in the same area. Other studies have shown similar variation in mortality rates by area, gear type and species (e.g. Cox-Rogers 2000, 2001; Gjernes *et al.* 1993). A recent review of hooking mortality rates in marine recreational fisheries found that studies conducted over the past 2 decades have shown mortality rates ranging from about 5% to well over 30% in tidal waters (Cox-Rogers 1999). Despite this variability, current hooking mortality rates used in BC fisheries are not gear, area or method specific, and are applied equally to all fisheries coastwide. It is clear from the results of this, and other studies, that failure to incorporate some aspect of this variation into management estimates of catch and release mortality undermines the validity of current procedures.

All previous studies of catch and release mortality in recreational fisheries have concluded that hooking location is the factor most associated with mortality (Cox-Rogers 1999). Rates of mortality are much higher for fish that are hooked in the deep mouth where injury to the blood vessels associated with the throat, heart and gill arches can occur. Our results confirm this finding as 86.2% of coho and 84.6% of chinook immediate landed mortalities were hooked in the deep mouth. While the degree of bleeding was also highly associated with mortality rates bleeding is a direct result of hooking location and not really a separate factor.

Several factors appear to influence hooking location. Cox-Rogers (2000) found that the proportion of coho hooked in the deep mouth was higher for motor-mooched herring, compared to trolled herring or artificial lures and suggested that mooched baits were more easily ingested by coho than trolled lures or baits. McNair (1999) found similar results and proposed that more passive presentations cause higher hooking mortality rates by making it easier for salmon to ingest baits or lures. In the current study, the vast majority of anglers used a single gear type

(trolling with downrigger and lure) which precluded an assessment of the effect of gear type on hooking location.

The effect of fish size on hooking mortality was assessed in the current study and it was found that coho mortalities were significantly smaller than coho released alive. Gjernes *et al.* (1993) found a similar result and suggested that smaller fish may show higher mortality rates due to the relative size of the hook. They speculated that proportionally larger hooks are more likely to wound sensitive areas such as gills, large blood vessels or the brain. However, it should be noted that their study focused on juvenile salmon in their first year of ocean life and most fish were less than 30 cm in length. Other studies have found the reverse to be true reporting higher mortality rates on larger fish (Cox-Rogers 2000, Muoneke and Childress 1994, McNair 1999) and have suggested that fish size affects hooking location as larger fish are more easily able to ingest baits into the deep mouth areas. While it is clear that fish size plays some role in hooking mortality rates, the mechanism underlying this result is not entirely clear.

The loss of scales due to handling had a significant effect on the chinook mortality rate. Since chinook are a larger fish, they may pose more of a handling problem, especially for inexperienced anglers. This would likely result in more fish being netted, as was the case in this study. The struggling of these larger fish in a landing net likely increased scale loss and contributed to the mortality rates that were observed for chinook.

Angler activity had a significant effect on the chinook mortality rate. Behavioural differences between chinook and coho may result in anglers engaging in different actions to ensure hook-ups. As chinook may be less aggressive in taking the bait anglers seem to choose strategies such as feeding line to ensure hook-ups occur. This activity appears to lead to higher mortalities as fish fed line tend to take the hook into deep mouth areas where injury to gills or large blood vessels is more likely to occur.

The immediate landed mortality rates observed in the current study were higher than those recorded for other studies conducted on adult chinook and coho in British Columbia and higher than the values currently used for management purposes (10% for coho, 15% for chinook; Cox-Rogers 1999). This result may simply be a reflection of the degree of variation noted above or it may be that the inclusion of volunteer anglers of all levels of experience in a study of hooking mortality rates influenced the outcome. It is clear that less experienced fishers tend to take longer to play fish, use landing nets more frequently, take longer to remove hooks, and generally handle fish more roughly. These factors can influence mortality rates and while they are reflective of the true nature of recreational fisheries, they may not have been included in all previous studies. Cox-Rogers (2001) has stated that the hooking mortality rates presented in his study should be considered as minimum values, as handling is much more stressful in the actual angling population. The current study was designed to incorporate this factor by utilizing anglers with a wide range of fishing experience and we are confident that the results presented reflect typical angling practices.

LANDED – DELAYED MORTALITY

While delayed short term mortality rates were determined for chinook (50%) and coho (12%), the chinook rate is of limited value as only 4 fish were held in the net pen. Mortality rates for coho were similar to those observed in other studies; however, no one factor was significantly related to condition at release. Only the condition of coho arriving at the net pen had an impact on the mortality rate. This may be reflective of the inclusion of all factors (hook location, bleeding, handling, angler activity) on the arrival condition. While one factor alone may not have impacted the mortality rate their combined influence likely effected the overall condition as assessed at arrival. The result of this interaction was observed in the significant relationship between arrival condition and delayed mortality.

Coho that were held at the net pen to determine short term delayed mortality were larger than the landed population. As there is a demonstrated relationship between size and mortality the results of the net pen study may include a bias; however, it should be noted that while the current study found higher immediate mortality rates for smaller coho some previous studies have found the opposite result. As a consequence, it is difficult to determine the direction of any bias in mortality rates that may be present. It is recommended that future studies ensure that fish selected for an assessment of delayed mortality are representative of the total landed population.

NON-LANDED MORTALITY– MARINE MAMMAL PREDATION

Non-landed mortality (or drop off mortality) rates are difficult to assess and few attempts have been made to estimate this component of hooking mortality. However, several studies have shown that exhaustive exercize, such as that associated with angling, may lead to pronounced physiological disturbances that could contribute to delayed mortality (Brobbel *et al.* 1996). Given the high level of metabolic exhaustion after capture, there is a concern that released fish will not be able to escape predators (Farrell *et al.* 2000). A recent study has documented the dramatic increase in the harbour seal population in the Strait of Georgia (Olesiuk 1999), while earlier research of harbour seal diets found that adult salmon were the third most important prey item (Olesiuk *et al.* 1990). Further, anecdotal evidence suggests that seal encounters are common when angling for salmon in the lower Strait of Georgia. With these factors in mind, the current study set out to document the occurrence of seal encounters by anglers and to estimate the potential impact on non-landed hooking mortality.

The overall marine mammal encounter rate (encounters per fish hooked) by anglers participating in the study was 0.054. Encounters per fishing trip were higher at the start of the program when the fewest trips occurred. This pattern of temporal variability indicates that the overall marine mammal encounter rate observed in the current study may be an underestimate as it appears that more seals were present earlier in the fishing season. It is recommended that future studies begin observations earlier in the season in order to incorporate the observed temporal variation in predator densities.

Total predator encounter rates were higher for chinook (0.108) than for coho (0.032). This may have occurred due to the much longer average elapsed time from hook-up to landing for chinook (6 min 39 s) as opposed to coho (3 min 45 s). The extended time on the hook likely allowed seals more time to key in on fighting chinook and to make successful attacks before the fish were boated.

While the majority of fishing trips in the marine mammal predation study occurred in Area 14, the seal encounter rate per fishing trip was much higher in Area 17. This pattern of spatial variability suggests that our estimate of the total marine mammal encounter rate is likely on the low side as the area of highest seal density was not well represented in the study. Data collected by creel survey technicians confirms this observation as seal encounter rates based on angler interviews between 1996 and 2001 averaged 30% for Area 17 and 17% for Area 14 (Hardie *et al.* 2002). It is recommended that future studies ensure adequate representation of each area in order to incorporate the observed spatial variation in predator densities.

Predation by marine mammals is only one source of non-landed mortality for angled salmon as long term effects and non-compliance also contribute to the overall rate. As a result, measured mortality rates due to predation should be considered as minimum values for managing recreational fisheries.

CONCLUSION

The current study revealed a surprisingly high immediate landed mortality rate for chinook and coho. This result must be seriously considered as selective fisheries become more prevalent. In traditional bag limit fisheries, landed mortalities are usually kept as part of a daily limit; however, when regulations prohibit keeping fish due to size, species or wild status restrictions immediate mortalities will be discarded. When this occurs, managers must adjust hooking mortality rates to reflect angling practices resulting from new regulations.

It is clear that setting coastwide hooking mortality rates does not appropriately reflect the spatial and temporal variability that exists. Current mortality rates may be appropriate for northern fisheries but greatly underestimate hooking mortality for the recreational fisheries operating in the southern Strait of Georgia. When all sources of hooking mortality are considered (21% immediate landed, 12% delayed landed, 3% non-landed predation) a rate of 10% appears to be inappropriate for coho in this fishery. Similarly, a summary of observed chinook hooking mortality rates (14% immediate landed, some delayed landed, 11% non-landed predation) indicates that a 15% rate is also underestimating true hooking mortality for chinook. It is clear that further study of this important subject is required, especially in areas of intense recreational fishing activity.

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Table 1. Gear choice of anglers participating in the 2001 hooking mortality study.

	Technique						Bait Type					
	Troll		Drift		Downrigger		Lure & Flash		Bait & Flash		Lure Only	
Species	N	%	N	%	N	%	N	%	N	%	N	%
Coho	310	100.0	0	0.0	310	100.0	294	94.8	8	2.6	8	2.6
Chinook	87	93.5	6	6.5	87	93.5	83	89.2	1	1.1	9	9.7
Total	397	98.5	6	1.5	397	98.5	377	93.6	9	2.2	17	4.2

	Lead Hook Type		Lead Hook Size					Trail Hook	
Species	Single	Treble	2/0	3/0	4/0	5/0	6	Yes	No
Coho	307	3	9	57	89	154	1	89	221
Chinook	86	7	8	35	17	22	11	8	85

Table 2. Landing rate, by area and species, for all fish hooked during the study.

Area 14

Species	Hook-ups	Landings	Landing Rate
Unknown	106	0	0.0%
Coho	818	390	47.7%
Chinook	121	71	58.7%
Total (all species)	1045	461	44.1%

Area 17

Unknown	9	0	0.0%
Coho	41	25	61.0%
Chinook	68	36	52.9%
Total (all species)	118	61	51.7%

Areas 14 and 17 Combined

Unknown	115	0	0.0%
Coho	859	415	48.3%
Chinook	189	107	56.6%
Grand Total	1163	522	44.9%

Note: Totals include fish landed but not sampled or completely assessed. See text for details.

Table 3. Immediate mortality rate, by area and species, for all coho and chinook landed.

Species	Landings	Mortalities	Mortality Rate	95% Lower CL	95% Upper CL
Area 14					
Coho	289	58	20.1%	16.0%	25.1%
Chinook	62	11	17.7%	9.2%	29.5%
Total (all species)	351	69	19.7%	16.0%	23.7%
Area 17					
Coho	21	7	33.3%	14.6%	57.0%
Chinook	31	2	6.5%	0.8%	21.4%
Total (all species)	52	9	17.3%	8.2%	30.4%
Areas 14 and 17 Combined					
Coho	310	65	21.0%	17.1%	25.8%
Chinook	93	13	14.0%	7.6%	24.8%
Grand Total	403	78	19.4%	16.0%	23.3%

Table 4. Release condition, by hooking location, for all coho and chinook landed.

COHO

	Hooking Location						Total
	Deep Mouth		Outer Mouth		Outside Mouth		
Release Condition	N	%	N	%	N	%	
1	0	0.0%	133	97.1%	4	2.9%	137
2	0	0.0%	77	89.5%	9	10.5%	86
3	0	0.0%	14	70.0%	6	30.0%	20
All Live Releases	0	0.0%	224	92.2%	19	7.8%	243
4	56	86.2%	8	12.3%	1	1.5%	65

CHINOOK

	Hooking Location						Total
	Deep Mouth		Outer Mouth		Outside Mouth		
Release Condition	N	%	N	%	N	%	
1	0	0.0%	53	94.6%	3	5.4%	56
2	0	0.0%	18	94.7%	1	5.3%	19
3	0	0.0%	4	100.0%	0	0.0%	4
All Live Releases	0	0.0%	75	94.9%	4	5.1%	79
4	11	84.6%	2	15.4%	0	0.0%	13

Note: Hooking location was not recorded for all fish therefore totals may not match other tables.

Table 5a. Release condition, by degree of bleeding, for all coho and chinook landed.

COHO

	Degree of Bleeding								
	None		Light		Moderate		Heavy		Total
Release Condition	N	%	N	%	N	%	N	%	
1	23	18.3%	74	58.7%	29	23.0%	0	0.0%	126
2	3	3.8%	42	53.2%	34	43.0%	0	0.0%	79
3	3	15.0%	11	55.0%	4	20.0%	2	10.0%	20
All Live Releases	29	12.9%	127	56.4%	67	29.8%	2	0.9%	225
4	1	1.6%	9	14.1%	41	64.1%	13	20.3%	64

CHINOOK

	Degree of Bleeding								
	None		Light		Moderate		Heavy		Total
Release Condition	N	%	N	%	N	%	N	%	
1	26	46.4%	26	46.4%	4	7.1%	0	0.0%	56
2	9	47.4%	2	10.5%	8	42.1%	0	0.0%	19
3	1	25.0%	3	75.0%	0	0.0%	0	0.0%	4
All Live Releases	36	45.6%	31	39.2%	12	15.2%	0	0.0%	79
4	1	7.7%	2	15.4%	9	69.2%	1	7.7%	13

Note: Degree of bleeding was not recorded for all fish therefore totals may not match other tables.

Table 5b. Release condition, by bleeding location, for all landed coho and chinook that exhibited bleeding.

COHO

	Bleeding Location										
	Eye		Jaw/Max.		Shallow Mouth		Deep Mouth		Gills		Total
Release Condition	N	%	N	%	N	%	N	%	N	%	
1	5	12.2%	28	68.3%	8	19.5%	0	0.0%	0	0.0%	41
2	3	12.5%	15	62.5%	6	25.0%	0	0.0%	0	0.0%	24
3	2	28.6%	5	71.4%	0	0.0%	0	0.0%	0	0.0%	7
All Live Releases	10	13.9%	48	66.7%	14	19.4%	0	0.0%	0	0.0%	72
4	2	6.7%	7	23.3%	5	16.7%	3	10.0%	13	43.3%	30

CHINOOK

	Bleeding Location										
	Eye		Jaw/Max.		Shallow Mouth		Deep Mouth		Gills		Total
Release Condition	N	%	N	%	N	%	N	%	N	%	
1	1	9.1%	6	54.5%	4	36.4%	0	0.0%	0	0.0%	11
2	0	0.0%	5	100.0%	0	0.0%	0	0.0%	0	0.0%	5
3	0	0.0%	0	0.0%	1	100.0%	0	0.0%	0	0.0%	1
All Live Releases	1	5.9%	11	64.7%	5	29.4%	0	0.0%	0	0.0%	17
4	0	0.0%	0	0.0%	3	37.5%	0	0.0%	5	62.5%	8

Note: Bleeding location was not recorded for all fish therefore totals may not match other tables.

Table 6. Comparison of the lengths (cm) of coho and chinook released alive versus immediate mortalities.

	Released Alive					Mortalities				
Species	N	Min.	Max.	Mean	SD	N	Min.	Max.	Mean	SD
Coho	189	22.0	70.0	53.6	7.32	52	21.0	64.0	49.6	9.53
Chinook	52	38.0	100.0	63.1	12.45	10	47.0	77.0	63.9	9.50

Note: Length was not recorded for all fish therefore totals may not match other tables.

Table 7. Release condition, by degree of scaling, for all coho and chinook landed.

COHO

	Degree of Scaling								
	None		Light		Moderate		Heavy		Total
Release Condition	N	%	N	%	N	%	N	%	
1	10	8.2%	91	74.6%	21	17.2%	0	0.0%	122
2	1	1.2%	58	70.7%	20	24.4%	3	3.7%	82
3	2	10.5%	10	52.6%	5	26.3%	2	10.5%	19
All Live Releases	13	5.8%	159	71.3%	46	20.6%	5	2.2%	223
4	2	3.3%	37	61.7%	16	26.7%	5	8.3%	60

CHINOOK

	Degree of Scaling								
	None		Light		Moderate		Heavy		Total
Release Condition	N	%	N	%	N	%	N	%	
1	12	22.6%	37	69.8%	4	7.5%	0	0.0%	53
2	5	26.3%	9	47.4%	5	26.3%	0	0.0%	19
3	0	0.0%	4	100.0%	0	0.0%	0	0.0%	4
All Live Releases	17	22.4%	50	65.8%	9	11.8%	0	0.0%	76
4	3	27.3%	3	27.3%	4	36.4%	1	9.1%	11

Note: Degree of scaling was not recorded for all fish therefore totals may not match other tables.

Table 8. Release condition, by angler activity, for all coho and chinook landed.

COHO

	Angler Activity						
	None		Strike		Fed Line		Total
Release Condition	N	%	N	%	N	%	
1	14	10.1%	121	87.7%	3	2.2%	138
2	4	4.7%	78	91.8%	3	3.5%	85
3	2	10.5%	16	84.2%	1	5.3%	19
All Live Releases	20	8.3%	215	88.8%	7	2.9%	242
4	2	3.2%	57	90.5%	4	6.3%	63

CHINOOK

	Angler Activity						
	None		Strike		Fed Line		Total
Release Condition	N	%	N	%	N	%	
1	27	47.4%	25	43.9%	5	8.8%	57
2	1	5.9%	14	82.4%	2	11.8%	17
3	0	0.0%	4	100.0%	0	0.0%	4
All Live Releases	28	35.9%	43	55.1%	7	9.0%	78
4	0	0.0%	10	76.9%	3	23.1%	13

Note: Angler activity was not recorded for all fish therefore totals may not match other tables.

Table 9. Holding times and short-term mortality rates for all coho and chinook captured in the 2001 hooking mortality study and held at the net pen facility.

		Holding Time (hours)				
Species	Total Held	Min.	Max.	Mean	Mortalities	Mortality Rate
Coho	50	24.0	29.0	25.9	6	12.0%
Chinook	4	25.0	30.0	27.8	2	50.0%
Total	54	24.0	30.0	26.0	8	14.8%

Table 10. Release condition, by arrival condition, for all coho held at the net pen facility.

	Arrival Condition								
	Good		Fair		Poor		Dead		
Release Condition	N	%	N	%	N	%	N	%	Total
Good	30	75.0%	8	20.0%	2	5.0%	0	0.0%	40
Fair	0	0.0%	4	100.0%	0	0.0%	0	0.0%	4
Poor	0		0		0		0		0
All Live Releases	30	68.2%	12	27.3%	2	4.5%	0	0.0%	44
Dead	3	50.0%	0	0.0%	1	16.7%	2	33.3%	6

Table 11. Release condition, by hooking location, for all coho held at the net pen facility.

	Hooking Location						
	Outside Mouth		Outer Mouth		Deep Mouth		
Release Condition	N	%	N	%	N	%	Total
Good	0	0.0%	36	90.0%	4	10.0%	40
Fair	0	0.0%	4	100.0%	0	0.0%	4
Poor	0	0.0%	0	0.0%	0	0.0%	0
All Live Releases	0	0.0%	40	90.9%	4	9.1%	44
Dead	0	0.0%	6	100.0%	0	0.0%	6

Table 12a. Release condition, by degree of bleeding, for all coho held at the net pen facility.

	Degree of Bleeding								
	None		Light		Moderate		Heavy		
Release Condition	N	%	N	%	N	%	N	%	Total
Good	2	5.0%	24	60.0%	13	32.5%	1	2.5%	40
Fair	0	0.0%	2	50.0%	2	50.0%	0	0.0%	4
Poor	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0
All Live Releases	2	4.5%	26	59.1%	15	34.1%	1	2.3%	44
Dead	0	0.0%	3	50.0%	3	50.0%	0	0.0%	6

Table 12b. Release condition, by bleeding location, for all coho held at the net pen facility that exhibited bleeding.

	Bleeding Location										
	Eye		Jaw/Max.		Shallow Mouth		Deep Mouth		Gills		Total
Release Condition	N	%	N	%	N	%	N	%	N	%	
1	0	0.0%	15	93.8%	0	0.0%	0	0.0%	1	6.3%	16
2	0	0.0%	2	100.0%	0	0.0%	0	0.0%	0	0.0%	2
3	0		0		0		0		0		0
All Live Releases	0	0.0%	17	94.4%	0	0.0%	0	0.0%	1	5.6%	18
4	1	25.0%	3	75.0%	0	0.0%	0	0.0%	0	0.0%	4

Note: Bleeding location was not recorded for all fish therefore totals may not match other tables.

Table 13. Release condition, by degree of scaling, for all coho held at the net pen facility.

	Degree of Scaling								
	None		Light		Moderate		Heavy		Total
Release Condition	N	%	N	%	N	%	N	%	
1	0	0.0%	31	77.5%	9	22.5%	0	0.0%	40
2	0	0.0%	4	100.0%	0	0.0%	0	0.0%	4
3	0		0		0		0		0
All Live Releases	0	0.0%	35	79.5%	9	20.5%	0	0.0%	44
4	0	0.0%	4	66.7%	2	33.3%	0	0.0%	6

Table 14. Release condition, by angler activity, for all coho held at the net facility.

	Angler Activity						
	None		Strike		Fed Line		Total
Release Condition	N	%	N	%	N	%	
1	2	5.0%	37	92.5%	1	2.5%	40
2	0	0.0%	4	100.0%	0	0.0%	4
3	0		0		0		0
All Live Releases	2	4.5%	41	93.2%	1	2.3%	44
4	0	0.0%	6	100.0%	0	0.0%	6

Table 15. Marine mammal encounter rate per fishing trip, by three-week period.

Period	Number of Fishing Trips	Number of Marine Mammal Encounters	Encounters Per Fishing Trip
June 13 to July 3	6	5	0.83
July 4 to July 24	4	7	1.75
July 25 to Aug 14	6	3	0.50
Aug 15 to Sept 4	62	7	0.11
Sept 5 to Sept 25	49	5	0.10
Sept 26 to Oct 9	17	2	0.12
Total	144	29	0.20

Table 16. Marine mammal encounters, by salmon species hooked and encounter type, during the 2001 hooking mortality study.

	Encounter Impact Code								Total		Encounter
	One		Two		Three		Four		Mammal	Total	Rate per
Species	N	%	N	%	N	%	N	%	Encounters	Hook-ups	Hook-up
Coho	8	57.1	0	0.0	4	28.6	2	14.3	14	436	0.032
Chinook	3	27.3	3	27.3	2	18.2	3	27.3	11	102	0.108
Unknown	0	0.0	3	75.0	0	0.0	1	25.0	4		
Total	11	37.9	6	20.7	6	20.7	6	20.7	29	538	0.054

Table 17. Summary of gear use by recreational anglers in DFO statistical areas 14 and 17, for the years 1999 to 2001.

Chinook

	1999				2000				2001			
	Area 14		Area 17		Area 14		Area 17		Area 14		Area 17	
Gear	n	%	n	%	n	%	n	%	n	%	n	%
Troll with downrigger & bait	17	2.3	23	3.5	12	2.2	9	2.8	3	0.7	18	6.9
Troll with downrigger & lure	2	0.3	5	0.8	475	88.8	280	86.7	374	92.3	225	85.9
Troll with bait	643	87.6	539	82.0	0	0.0	4	1.2	1	0.2	0	0.0
Troll with lure	4	0.5	3	0.5	2	0.4	3	0.9	6	1.5	1	0.4
Mooching	6	0.8	8	1.2	3	0.6	1	0.3	1	0.2	2	0.8
Jigging	62	8.4	79	12.0	43	8.0	26	8.0	20	4.9	16	6.1
Total	734	100	657	100	535	100	323	100	405	100	262	100

Coho

	1999				2000				2001			
	Area 14		Area 17		Area 14		Area 17		Area 14		Area 17	
Gear	n	%	n	%	n	%	n	%	n	%	n	%
Troll with downrigger & bait	1	1.0	3	6.0	5	3.5	1	1.7	4	0.6	8	4.2
Troll with downrigger & lure	0	0.0	0	0.0	119	83.2	51	87.9	610	95.2	162	85.3
Troll with bait	85	85.9	39	78.0	2	1.4	0	0.0	0	0.0	0	0.0
Troll with lure	2	2.0	1	2.0	3	2.1	0	0.0	2	0.3	0	0.0
Mooching	1	1.0	0	0.0	0	0.0	1	1.7	3	0.5	2	1.1
Jigging	10	10.1	7	14.0	14	9.8	5	8.6	22	3.4	18	9.5
Total	99	100	50	100	143	100	58	100	641	100	190	100

Table 18. Results of contingency analyses examining the effect of several factors on hooking mortality.

Mortality Type	Hook Location	Bleeding	Fish Size	Scaling	Angler Activity
Landed - Immediate					
Coho	Significant	Significant	Significant	Not Significant	Not Significant
Chinook	Significant	Significant	Not Significant	Significant	Significant
Landed - Delayed					
Coho	Not Significant	Not Significant	N/A	Not Significant	Not Significant

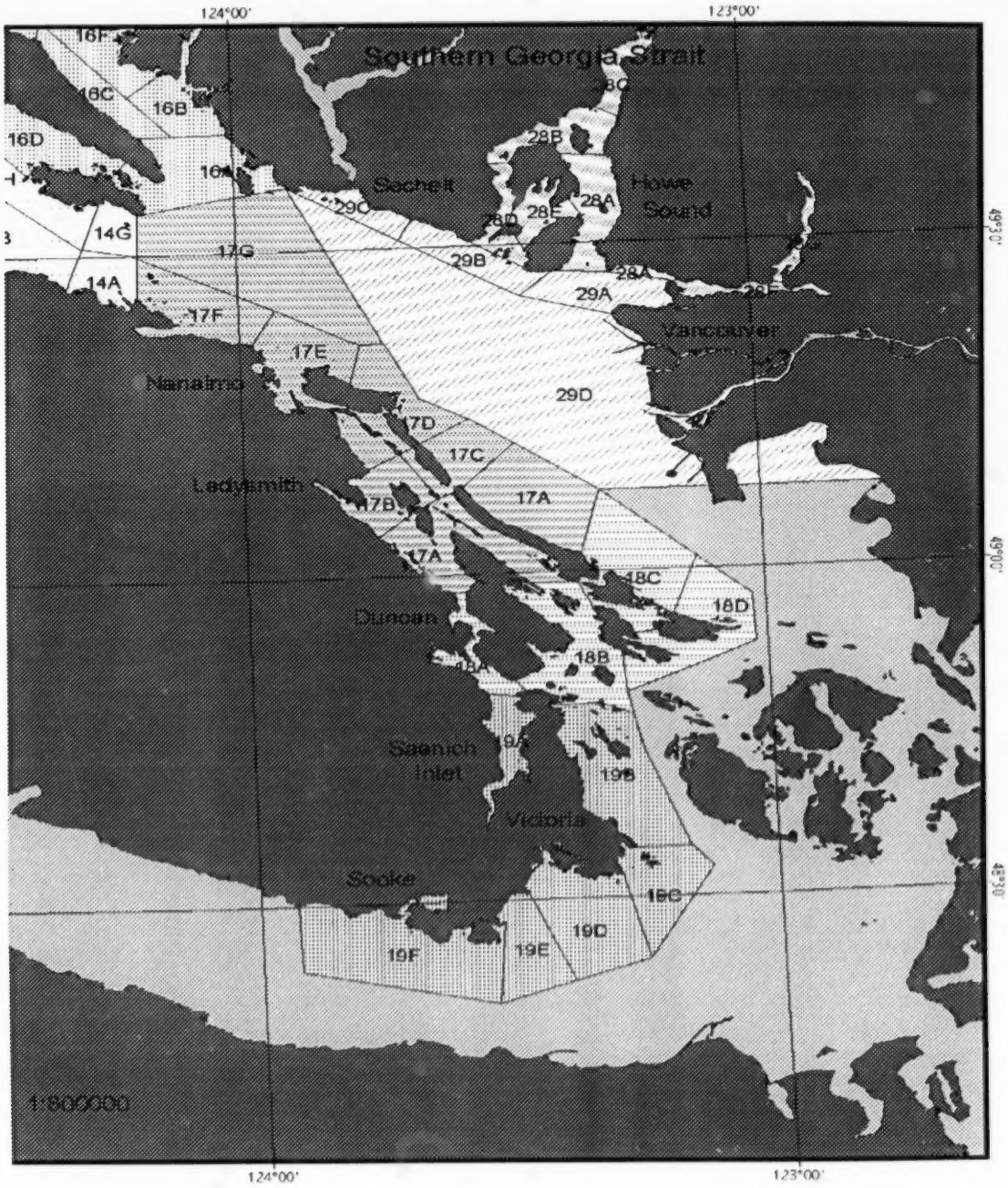

Figure 1. Recreational fishery statistical areas in Georgia Strait.

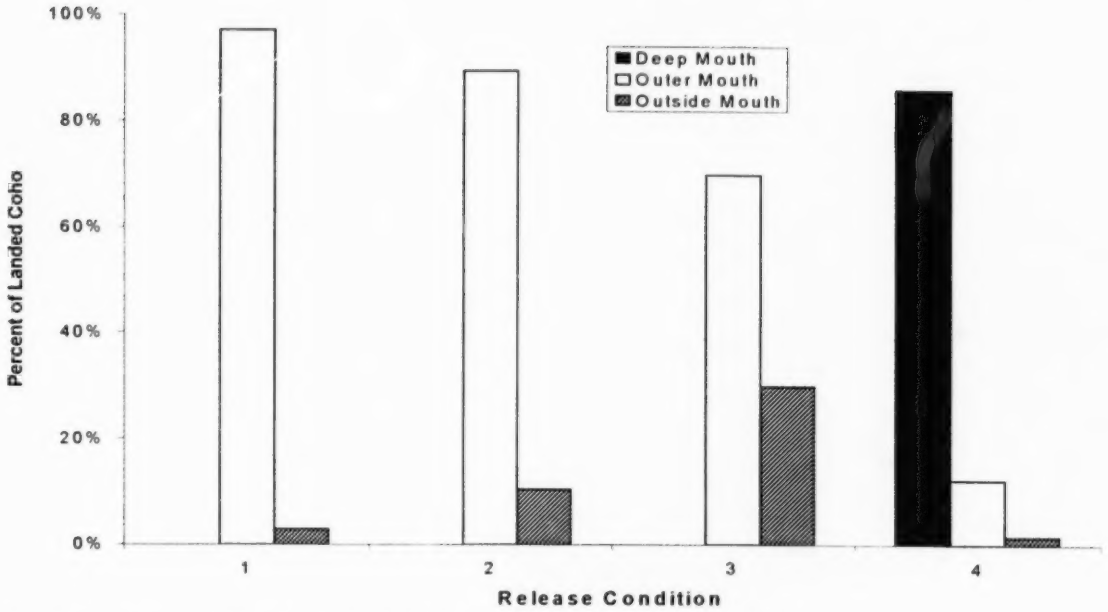

Figure 2. Release condition, by hooking location, for all coho landed.

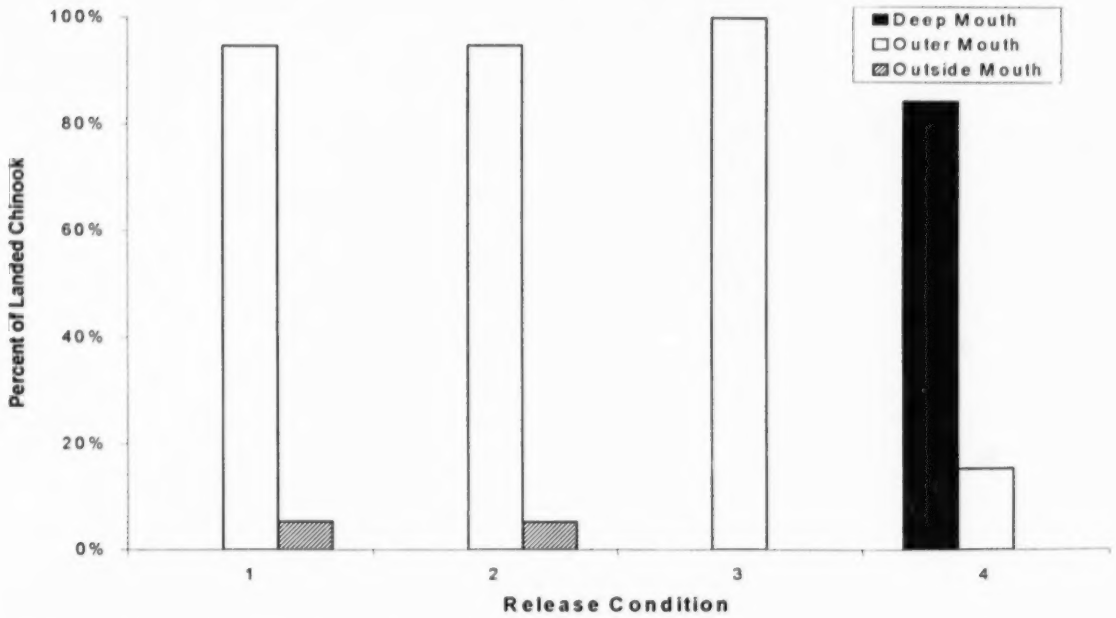

Figure 3. Release condition, by hooking location, for all chinook landed.

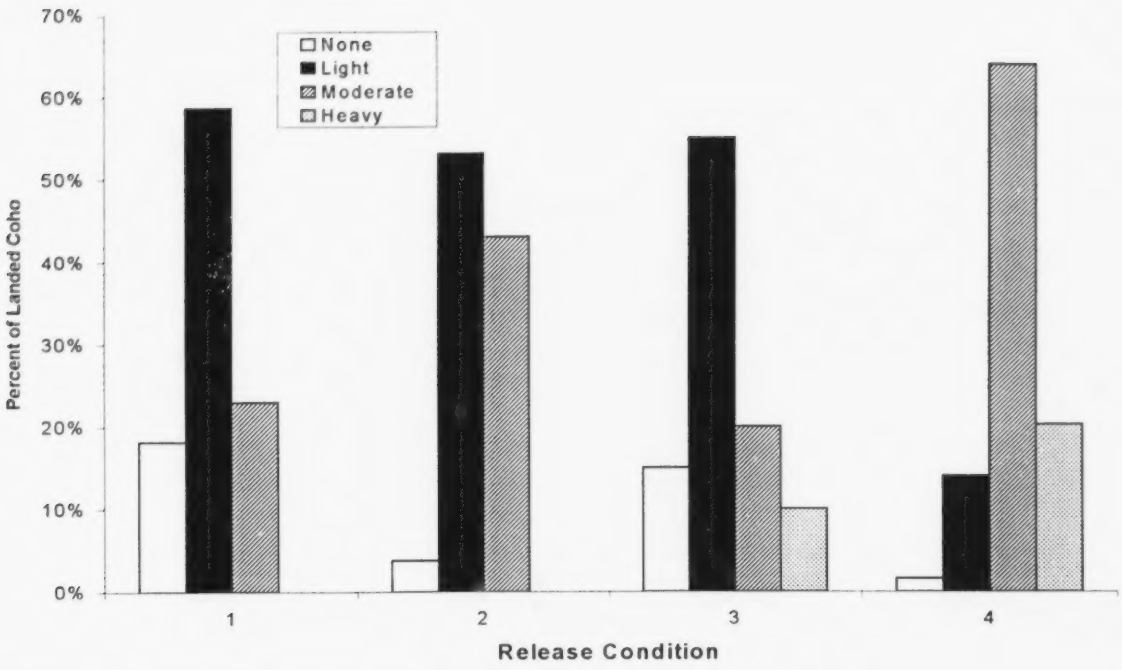

Figure 4. Release condition, by degree of bleeding, for all coho landed.

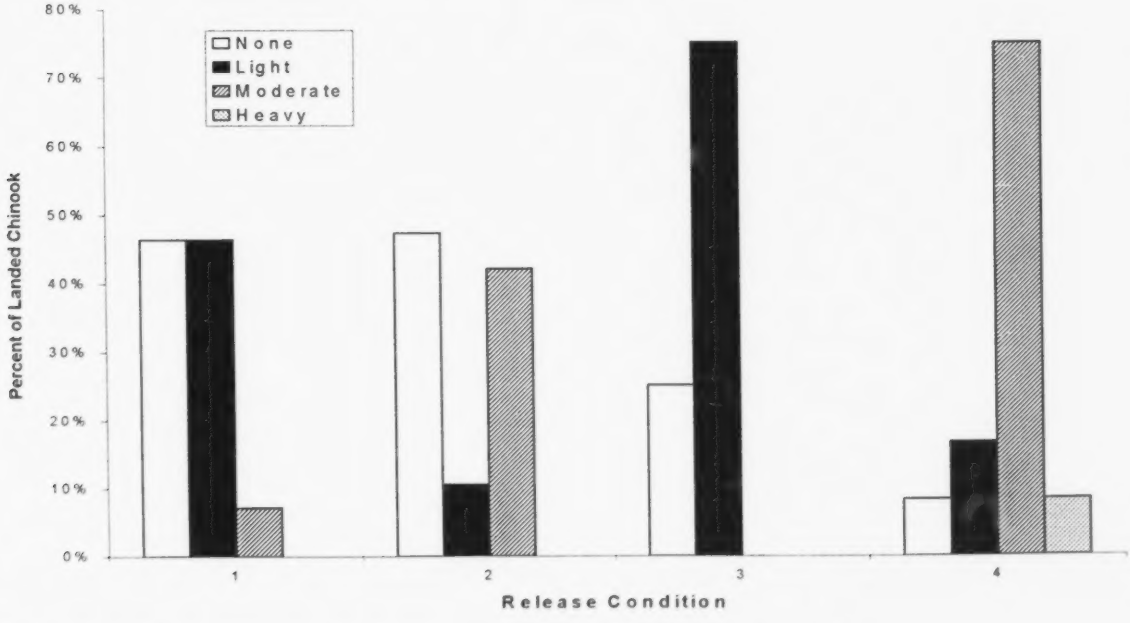

Figure 5. Release condition, by degree of bleeding, for all chinook landed.

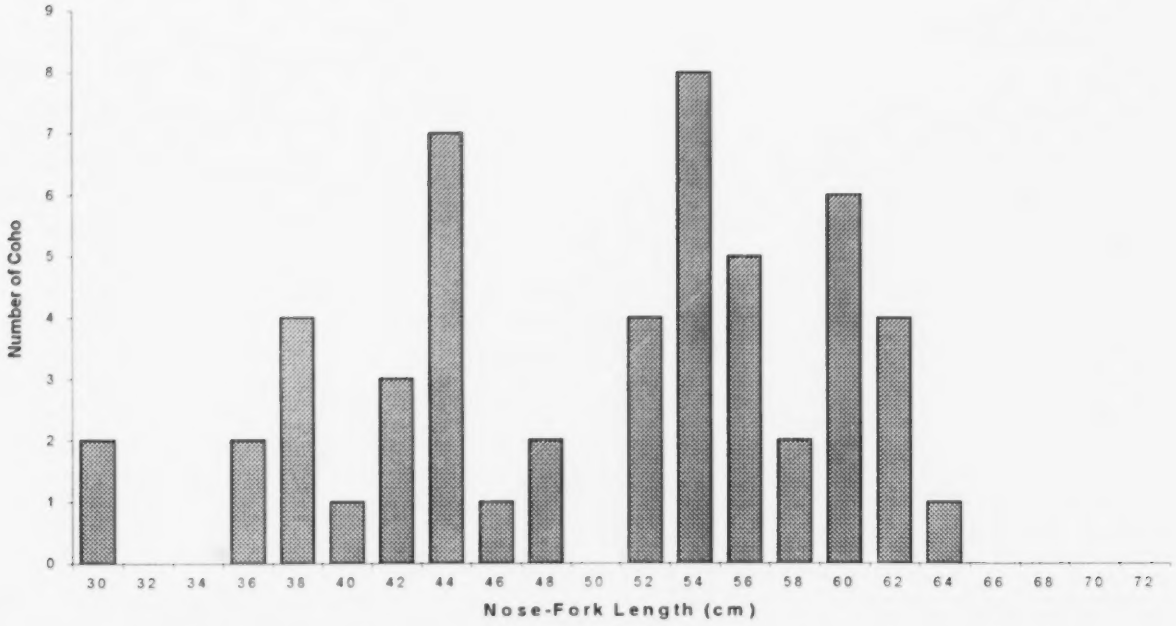

Figure 6. Length frequency distribution for all landed coho released alive.

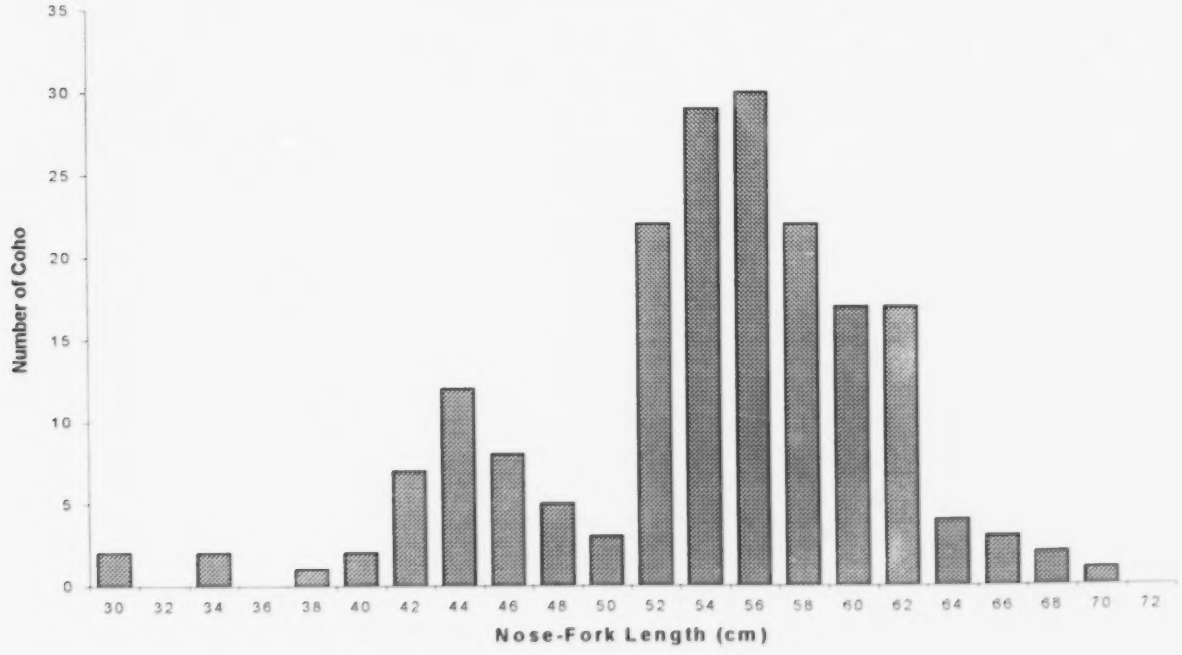

Figure 7. Length frequency distribution for all landed coho mortalities.

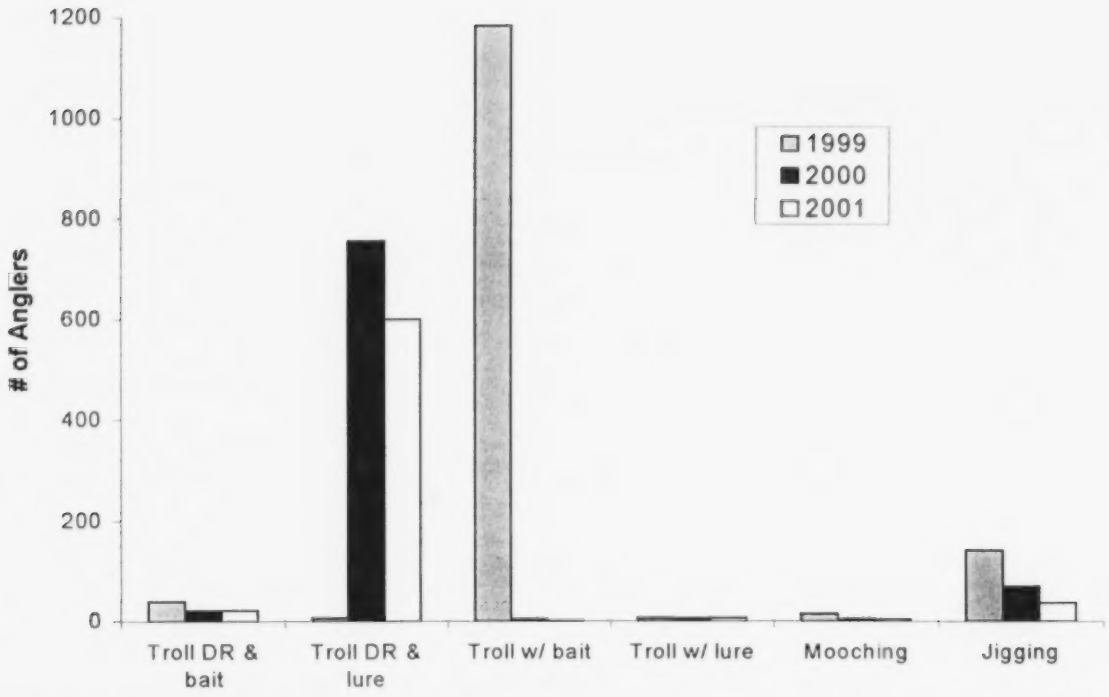

Figure 8. Gear choice of anglers fishing in DFO statistical areas 14 and 17 for the years 1999 to 2001.